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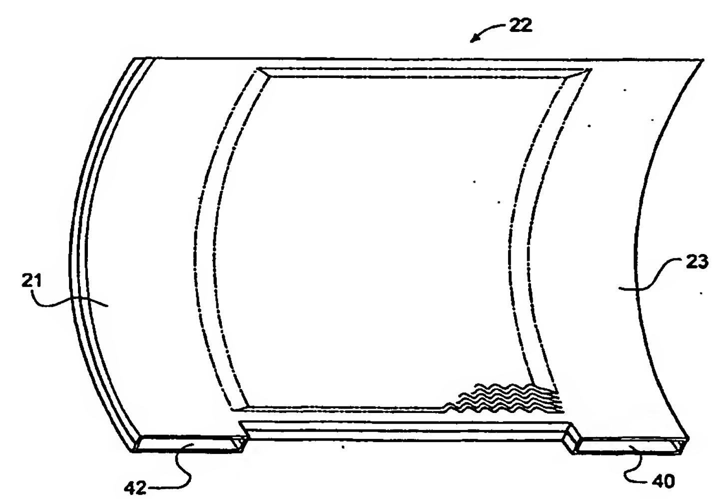

(57) Abstract

A heat exchanger, in which stationary metallic plates (12) are corrugated in cross–section and crushed around the perimeter, respective pairs of plates (12) being welded around their perimeters in the crushed region to form cells (22), the crushed region (30, 32) of the plates of a respective cell (22) being spaced apart at opposite ends to form headers (21, 23) which extend at an angle to the direction of the corrugations (17) of the corrugated plates (12), which headers (21, 23) are closed at one end and are open at the opposite end, and form, for the respective cell (22), the entry and exit ports for one of the gas streams, the open end of each header (21, 23) being attached by means of welding to the wall of a manifold system (44), such welding being the only means of attachment and rigid restraint of the individual cells (22) to the rest of the heat exchanger or to each other.

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CYLINDRICAL PLATE-TYPE HEAT EXCHANGER

Heat exchangers are used in gas turbine engines as a means of increasing efficiency by extracting heat from the exhaust gas and donating this heat to the compressed air leaving the compressor prior to its entering the combustion chamber. Such exchangers are of two general types, firstly the rotating disc type, commonly known as a regenerator and secondly, the static plate type commonly known as a recuperator, with which this invention is concerned.

In designing gas turbines of less than, say, one megawatt in output power, but more especially for small turbines of less than, say, 300 kilowatts output, space and weight become important factors. For this reason, an elegant and compact technical solution to the problem of integrating the heat exchanger with the rest of the gas turbine can be provided by surrounding the exhaust region of the engine with a heat exchanger which is annular in cross section. Such heat exchangers have to withstand the considerable temperature experienced in the exhaust gases, which might be up to 700°C, and the high pressure of the compressed air which might be up to eight times atmospheric.

The present invention seeks to provide a method of construction of such an annular heat exchanger which is compact, light weight, relatively cheap to manufacture and technically more reliable than designs provided hitherto.

According to a first aspect of the present invention there is provided a heat exchanger in which heat is extracted from a first gas stream at a first

temperature and donated to a second gas stream at a second temperature lower than the first temperature by heat conduction through stationary metallic plates, in which heat exchanger the plates are corrugated in cross-section and are crushed around the perimeter, respective pairs of plates being welded around their perimeters in the crushed region to form cells, the crushed region of the plates of a respective cell being spaced apart at opposite ends to form headers which extend at an angle to the direction of the corrugations of the corrugated plates, which headers are closed at one end and are open at the opposite end and form, for the respective cell, the entry and exit ports for one of the gas streams, the open end of each header being attached by means of welding to the wall of a manifold system, such welding being the only means of attachment and rigid restraint of the individual cells to the rest of the heat exchanger or to each other.

Preferably, the first gas stream comprises the exhaust gases of a gas turbine and the second gas stream comprises the compressed air of the said gas turbine prior to its entering the combustion chamber of said turbine.

Preferably, the manifold system is substantially cylindrical, the cells extending outwardly from the manifold system to form an annular heat exchanger matrix. The cells may be curved. Each cell may, for example, project from the manifold system at an angle to a respective radial plane and diverge further from the radial plane as it extends outwardly from the manifold system. The cells may increase in thickness as they project outwardly from the manifold system. This may be achieved by progressively increasing the amplitude of the corrugations of the corrugated plates

as they project outwardly from the manifold system. Because the cells are curved and/or become progressively thicker, they occupy a greater proportion of the volume of the annulus defined by the annular heat exchanger matrix than they would if they were straight and of constant thickness, and with particular curvature and/or taper characteristics they are able to occupy the whole of the volume of the annulus.

Preferably, the expansion of the cells due to heat or internal pressure is restrained by means of a loosely fitting cylindrical outer casing which fits over the radially outer ends of the cells. Preferably, the cells are adapted so that the contact point or points between the outer edges of the cells when under expansion due to heat and/or pressure forces and the cylindrical outer casing occur at a desired axial position along the cylindrical outer casing.

Preferably, means is provided for directing the second gas stream into a first set of headers at one end of the manifold system and, after flowing through the interior of the cells in a generally axial direction for directing the second gas stream out through a second set of headers at the other end of the manifold system.

Preferably, exhaust means is provided to direct the first gas stream between adjacent cells of the heat exchanger matrix in a direction generally axial to a centreline of the cylindrical header arrangement, but in a counter direction to that of the second gas stream.

The manifold system and/or the headers may be made from a different material from that of the plates.

The open ends of respective headers may abut one another and may be welded together to form at least a part of the manifold system.

Preferably, the corrugations of the corrugated plates follow an oscillating path, so that the corrugations define a wave pattern when viewed in a direction normal to the surface of the plate. Preferably, the wave pattern of plates in adjacent cells criss-crosses to avoid interlocking of adjacent cells.

Preferably, the crushing of the corrugations of each corrugated plate take place to a plane equidistant between the top and bottom of the corrugations.

Preferably, the plates of respective cells are spaced apart by means of spacer bars which may be welded to the plates. Alternatively, the plates of a respective cell may be spaced apart by a bent over portion of one of the plates or by bent over portions of both plates. The bent over portions may be welded to the adjacent plate or may alternatively be welded together.

According to a second aspect of the present invention, there is provided a heat exchanger in which heat is extracted from a first gas stream at a first temperature and donated to a second gas stream at a second temperature lower than the first temperature by heat conduction through stationary metallic plates forming a heat exchanger matrix, the plates being welded around headers formed on one side of the plates to a manifold arrangement, such welding being the only means of attachment of the plates to the rest of the heat exchanger or to each other.

Preferably, each plate is corrugated in cross-section

and is crushed around the perimeter. Preferably, the corrugations of the corrugated plates follow an oscillating path, so that the corrugations define a wave pattern when viewed in a direction normal to the surface of the plate. Pairs of plates may be welded around their perimeters in the crushed region to form cells. The plates may be spaced apart in the non-welded portion of the crushed region, the spaced apart portions forming walls of transversely extending headers which are closed at one end and are opened at the opposite end to form entry and exit ports for one of the gas streams.

The open end of each header may be welded directly to the manifold system, such welding being the only means of attachment and rigid restraint of the individual cells to the rest of the heat exchanger or to each other.

According to a third aspect of the present invention there is provided a heat exchanger comprising a plurality of heat exchanger cells connected to and extending from a common manifold, the cells increasing in thickness as they extend outwardly from the manifold. Preferably, the heat exchanger cells comprise corrugated heat exchanger plates. Preferably, the corrugations of the corrugated plates increase in amplitude as they project outwardly from the manifold, thereby causing the thickness of the cells to increase as they project outwardly from the manifold.

Preferably, the heat exchanger comprises an annular heat exchanger matrix formed from the heat exchanger cells. Because the cells become progressively thicker as they project outwardly from the manifold system, they occupy a greater proportion of the volume of the

annulus defined by the annular heat exchanger matrix than they would if they were of constant thickness, and with particular taper characteristics, they are able to occupy the whole of the volume of the annulus.

In addition to increasing in thickness as they project outwardly from the manifold, the cells may be curved. Each cell may, for example, project from the manifold at an angle to a respective radial plane and diverge further from the radial plane as it extends outwardly from the manifold.

Embodiments in accordance with the third aspect of the present invention may have some or all of the preferred features of the first and second aspects of the present invention.

For a better understanding of the present invention and to show how it may be carried into effect, reference will now be made, by way of example, to the accompanying drawings in which:-

Figure 1(a) is a cross-section through a heat exchanger surrounding a gas turbine engine exhaust system;

Figure 1(b) is a cross-section through the heat exchanger of Figure 1 taken along the line X-X;

Figure 2(a) shows a single corrugated heat exchanger plate;

Figure 2(b) shows a heat exchanger plate having the corrugations crushed around its periphery;

Figure 3(a) is an enlarged view of the corrugations of the heat exchanger plate of Figures 2(a) and 2(b);

Figure 3(b) is an enlarged perspective view of part of a corrugated heat exchanger plate which has been crushed around its periphery.

Figure 4(a) shows one method of joining two adjacent heat exchanger plates to form a heat exchanger cell;

Figure 4(b) shows an alternative method of joining two adjacent heat exchanger plates to form a heat exchanger cell;

Figure 4(c) shows how a curved heat exchanger plate may be bent over and fusion welded to the adjacent heat exchanger plate at the outer diameter of the annulus;

Figure 5 is a perspective view of a complete heat exchanger cell;

Figure 6 is an enlarged view of the connection of respective heat exchanger cells with a cylindrical manifold system;

Figure 7 is a perspective view of the entire heat exchanger matrix attached to the cylindrical manifold system prior to its entry into the cylindrical outer casing;

Figure 8(a) is a cut-away view showing how the open ends of adjacent headers may be enlarged and welded together to form part of the cylindrical manifold system;

Figure 8(b) shows how adjacent headers are welded together where they abut; and

Figure 9 shows an alternative embodiment of heat

exchanger cell in which the headers are formed separately from the plates.

Figure 10 shows an alternative embodiment of tapered heat exchanger cell in which the thickness of the cell progressively increases as it extends outwardly from the inner cylindrical casing.

The invention is best described by reference to Figs. 1 (a) & 1 (b) which show two cross sectional views of a heat exchanger surrounding the axis of a gas turbine engine exhaust system. The heat exchanger comprises a matrix, 10, cross hatched in Fig. 1(a), which is generally rectangular in cross section when viewed at right angles to the engine axis as in Fig. 1 (a) and annular in cross section when viewed parallel to the axis of the engine as in Fig. 1 (b). The matrix 10 consists of a series of stacked corrugated metallic plates 12 arranged in curved shapes to from an annulus 24 in such a manner as to provide a means whereby heat can be transferred by conduction from one side of a plate 12 in contact with the exhaust gas to the other side of a plate 12 in contact with the compressed air. At the ends of the matrix 10, the corrugated plates 12 are crushed or flattened in areas 15 and 20 to form entry headers 21, 23 for the gases to pass into the matrix 10 as described subsequently. Hot exhaust gas enters the matrix via the duct 11, passes through the matrix 10 in a generally axial direction and leaves via duct 14. Compressed air enters the matrix 10 via the duct 16 and passes through the matrix 10 in a generally axial direction, which is counter to the direction of flow of the exhaust gases, and leaves via duct 18.

Such a general configuration of flow through an annular matrix 10 made up of curved plates 12 is not new, but

the method of construction of the plates 12 and their method of fixing in order to achieve sealing and to permit freedom to expand under temperature without the introduction of serious thermal stress, is novel and forms the basis of this invention.

For a better consideration of the invention, reference is made to Fig. 2(a), which shows a single corrugated plate 12 and to Fig. 2(b), which shows the same plate 12 which has had the corrugations 17 crushed around its periphery. The corrugations 17 of the plate 12 are generally U shaped in cross section, as shown in 3(a), and may be either straight in a longitudinal direction but preferably wavy in a longitudinal direction, to give increased turbulence to the gases and consequently better heat transfer. The crushing takes place to the plane P equidistant between the top and bottom of the corrugations 17 as shown in Fig. 3(b).

The purpose of the crushing is firstly to provide a means whereby two adjacent plates 12 may be joined together by welding around the edge, to form a cell 22 and also by crushing over a relatively wide area at 30 and 32, to provide entry headers 21, 23 for the gases to pass into the matrix 10, whilst maintaining separate passages between the donor and recipient gases. Figs. 4(a) and 4(b) show how two adjacent plates 12 may be joined together to form a cell 22. Fig. 4(a) shows the two crushed surfaces of adjacent plates 12 being welded together by means of a spacer bar 25. Figs. 4(b) and 4(c) show the plates 12 being fusion welded together at the extremity of their bent over edges 26, 29. Fig. 5 shows a complete cell 22 formed by either of the above described welding means.

It will be seen from Fig. 5 that the welding takes

place around the periphery in such a manner as to seal the cell 22 completely except for two rectangular mouths 40 and 42, which provide entry and exit ports for the compressed air from the compressor to pass in and out of the inside of the cell 22. Fig. 6 shows how these entry ports may be made to fit and fasten, by means of welding, to equivalent rectangular slots in a cylindrical inner wall 43 of the heat exchanger, to form part of a manifold system 44 enabling gases to enter and leave the insides of the cells 22 of the matrix 10 via ducts 16 and 18.

When a multiplicity of such cells 22 are joined to the inner cylindrical wall 43 by the above welding procedure so as to occupy its complete circumference, they form the entirety of the matrix 10. No other welding is necessary to join the cells together.

If now the cells 22 are formed in a curved shape as shown in Fig. 1 (b), they can be made to occupy the whole of an annulus 24. This then enables a cylindrical outer casing 45 of the heat exchanger to be freely placed into position around the cells 22, in loose contact with the cells 22, restraining the cells 22 in an annular configuration, but not rigidly connected to them. Each cell 22 is, therefore, free to expand individually under temperature and pressure conditions, being only rigidly restrained at the inner diameter of the annulus 24 and since the fitting of the outer diameter of the cells 22 with the outer casing 45 is fairly loose, thermal stresses in the heat exchanger matrix 10 are minimised. The outer casing 45 serves as a support for withstanding the pressure forces inside the cells 22, which tend to straighten their curved shapes under operating conditions, but otherwise, it imposes no rigid restraint on the cells 22. This

cylindrical outer casing 45 is held in axial disposition with the matrix 10 and inner cylindrical casing 43 by means of a flange connection to the final gas discharge casing 28. Moreover, its loose fit with the outer edges of the cells 22 can be arranged in such a manner that the contact point or points between the cells 22 and the casing 45 when the cells 22 are under operating conditions can be at any desired point or points along the axial length of the casing 45. Fig.7 shows a view of the entire matrix 10 attached to the inner cylindrical casing 43 prior to its entering the cylindrical outer casing 45.

It is this feature of having the cells 22 of the matrix 10 free to expand individually from their sole area of rigid fixing at the inner cylindrical casing 43 around their rectangular shaped mouths 40 and 42 that distinguishes this invention from other art relating to welded heat exchanger matrices. In particular, attention is drawn to U.S. Patent No: 5060721 granted to Charles J. Darragh on October 29th, 1991, where an annular matrix having curved cells is formed by rigidly welding the cells together at their corners. In the preferred method of that invention, the flow through the matrix is radial leading to a design configuration which requires the corners of the cells to be welded rigidly together for stability but such a process is not necessary in the present invention by virtue of the axial flow configuration and the fact that the individual cells 22 are gently constrained under pressure forces by the loosely fitting cylindrical outer casing 45.

Having described how the compressed air enters and leaves the inside of the cells 22 forming the matrix 10, via ports 40 and 42 which are fixed by welding to

the inner cylindrical manifold system 44, it should be pointed out that the exhaust gases enter the corrugations 17 of the matrix 10 between adjacent cells 22 via the duct 11 and through the flattened header system at 60, Fig.6. Since the cells 22 are completely sealed by virtue of their connection at ports 40 and 42 to the inner cylindrical manifold system 44, no leakage between the compressed air and exhaust gases can take place.

The flattened header system 60 may be reinforced against pressure forces by the use of separate individual corrugated spacer pieces inserted between cells in the flattened areas 15 and 20.

One problem which may be encountered in matrices 10 having plates 12 made of corrugated curved shapes is that the geometry of two adjacent plates 12 fitting together on a curved path predicates that at some point along that path the valley of a corrugation 17 on one plate 12 will coincide with the crest of a corrugation 17 of an adjacent plate 12. This can lead to interlocking of adjacent plates 12 under operating conditions and can set up undesirable stresses in the plates 12. A method of avoiding this problem where longitudinally wavy shaped corrugations 17 are used, is to provide that the adjacent plates 12 of adjacent cells 22 are arranged to have the crests of the waves on one plate 12 to be in line with the troughs of the waves of the adjacent plate 12, i.e. to be displaced axially to one another by one half of a single wave pitch. This ensures that the serrations of adjacent plates 12 in adjacent cells 22 can never lock up and it also provides for greater turbulence of flow in the gases leading to better heat transfer.

In another variant of the invention the generally rectangular shaped mouths can be increased in size on their narrow sizes to such an extent that the mouths of adjacent cells 22 touch each other when placed at the pitching relating to the number of cells 22 required at the inner diameter of the annulus 24. This enables the mouths to be welded to each other along their long sides and to the inner cylindrical casing 43 on their short sides. This implies that the inner cylindrical casing 43 will be in three sections, a central portion 50 in between the two sets of mouths and two end portions 52, 54 connected to the casing flanges 56, 58. The concept is shown in Fig. 8 and its advantage is that it eliminates the need for rectangular slots in the cylindrical inner casing 43.

In any of the aforementioned variants of the basic concept, the header areas 15 and 20 are formed by crushing the corrugated plates 12. However, it is also possible to construct these header areas 70 and 80 Fig. 9, which contain the rectangular shaped mouths by forming them from homogenous sheet material and attaching them by means of welds 90 and 100 to the crushed material as shown in Fig. 9. This enables them to be made in material of any desired thickness, instead of the thickness consequential from the crushing of the corrugations 17, and may make attachment to the cylindrical inner casing 43, by any of the aforementioned methods, easier. Headers produced by this method may be reinforced in any desired way to withstand pressure.

Figure 10 shows an alternative embodiment in which, instead of the cells 22 of the heat exchanger matrix being curved, the thickness t of each cell increases as it extends outwardly from the inner cylindrical casing

43. This is achieved by progressively increasing the amplitude of the corrugations of the heat exchanger plates from a minimum amplitude 'a' adjacent the inner cylindrical casing 43 to a maximum amplitude 'A' adjacent the outer casing 45.

Embodiments are also contemplated in which the heat exchanger cells 22 are not only curved, but are also tapered and become progressively thicker as they extend from the inner cylindrical casing 43 towards the outer casing 45. Thus, at one extreme the cells are straight, extend radially outwardly and increase in thickness progressively, so that adjacent cells touch for their full length and completely fill the space between the inner cylindrical casing 43 and the outer casing 45. At the other extreme, illustrated in Figures 1 to 9, the thickness of the cells remains constant and the cells are curved to form a full involute matrix which again completely fills the space between the inner cylindrical casing 43 and the outer casing 45. In between these two extremes are embodiments in which the thickness of the cells progressively increases and the cells are also curved. The combined effects of taper and curvature can be adjusted so that the space between the inner cylindrical casing 43 and the outer casing 45 is completely filled, to maximise the efficiency of the heat exchanger matrix.

<u>CLAIMS</u>

1. A heat exchanger in which heat is extracted from a first gas stream at a first temperature and donated to a second gas stream at a second temperature lower than the first temperature by heat conduction through stationary metallic plates, in which heat exchanger the plates are corrugated in cross-section and are crushed around the perimeter, respective pairs of plates being welded around their perimeters in the crushed region to form cells, the crushed region of the plates of a respective cell being spaced apart at opposite ends to form headers which extend at an angle to the direction of the corrugations of the corrugated plates, which headers are closed at one end and are open at the opposite end and form, for the respective cell, the entry and exit ports for one of the gas streams, the open end of each header being attached by means of welding to the wall of a manifold system, such welding being the only means of attachment and rigid restraint of the individual cells to the rest of the heat exchanger or to each other.

2. A heat exchanger as claimed in claim 1, in which the first gas stream comprises the exhaust gases of a gas turbine and the second gas steam comprises the compressed air of the said gas turbine prior to its entering the combustion chamber of said turbine.

3. A heat exchanger as claimed in claim 1, in which the manifold system is substantially cylindrical, the cells extending outwardly from the manifold system to form an annular heat exchanger matrix.

4. A heat exchanger as claimed in claim 3, in which the cells are curved.

5. A heat exchanger as claimed in claim 3 or 4, in which as the cells extend outwardly from the manifold system their thickness increases.

6. A heat exchanger as claimed in claim 5, in which as the cells extend outwardly from the manifold system the amplitude of the corrugations of the corrugated plates increases, thereby causing the thickness of the cells to increase.

7. A heat exchanger as claimed in any one of claims 4 to 6, in which the curvature and/or increasing thickness of the cells enables the cells to occupy the whole volume of the annulus defined by the heat exchanger matrix.

8. A heat exchanger as claimed in any one of the preceding claims, in which expansion of the cells due to heat or internal pressure is restrained by means of a loosely fitting cylindrical outer casing which fits over the radially outer ends of the cells.

9. A heat exchanger as claimed in claim 8, in which the cells are adapted so that the contact point or points between the outer edges of the cells when under expansion due to heat and/or pressure forces and the cylindrical outer casing occur at a desired axial position along the cylindrical outer casing.

10. A heat exchanger as claimed in any one of the preceding claims, in which means is provided for

directing the second gas steam into a first set of headers at one end of the manifold system and, after flowing through the interior of the cells in a generally axial direction, for directing the second gas steam out through a second set of headers at the other end of the manifold system.

11. A heat exchanger as claimed in any one of any one of the preceding claims when appendant to claim 3, in which exhaust means are provided to direct the first gas stream between adjacent cells of the matrix in a direction generally axial to a centreline of the cylindrical header arrangement but in a counter direction to that of the second gas stream.

12. A heat exchanger as claimed in any one of the preceding claims, in which the manifold system and/or the headers are made from a different material from that of the plates.

13. A heat exchanger as claimed in any one of the preceding claims, in which the open ends of respective headers abut one another and are welded together to form at least a part of the manifold system.

14. A heat exchanger as claimed in any one of the preceding claims, in which the corrugations of the corrugated plates follow an oscillating path, so that the corrugations define a wave pattern when viewed in a direction normal to the surface of the plate.

15. A heat exchanger as claimed in claim 14, in which the wave pattern of plates in adjacent cells

criss-crosses to avoid interlocking of adjacent cells.

16. A heat exchanger as claimed in any one of the preceding claims, in which the crushing of the corrugations of each corrugated plate takes place to a plane equidistant between the top and bottom of the corrugations.

17. A heat exchanger as claimed in any one of the preceding claims, in which the plates of a respective cell are spaced apart by means of spacer bars.

18. A heat exchanger as claimed in claim 17, in which the spacer bars are welded to the plates.

19. A heat exchanger as claimed in any one of claims 1 to 16, in which the plates of a respective cell are spaced apart by a bent over portion of one of the plates.

20. A heat exchanger as claimed in claim 19, in which the bent over portion is welded to the other plate of the cell.

21. A heat exchanger as claimed in any one of claims 1 to 16, in which the plates of a respective cell are spaced apart by bent over portions of both plates.

22. A heat exchanger as claimed in claim 21, in which the bent over portions are welded together.

23. A heat exchanger substantially as described herein, with reference to, and as shown in the

accompanying drawings.

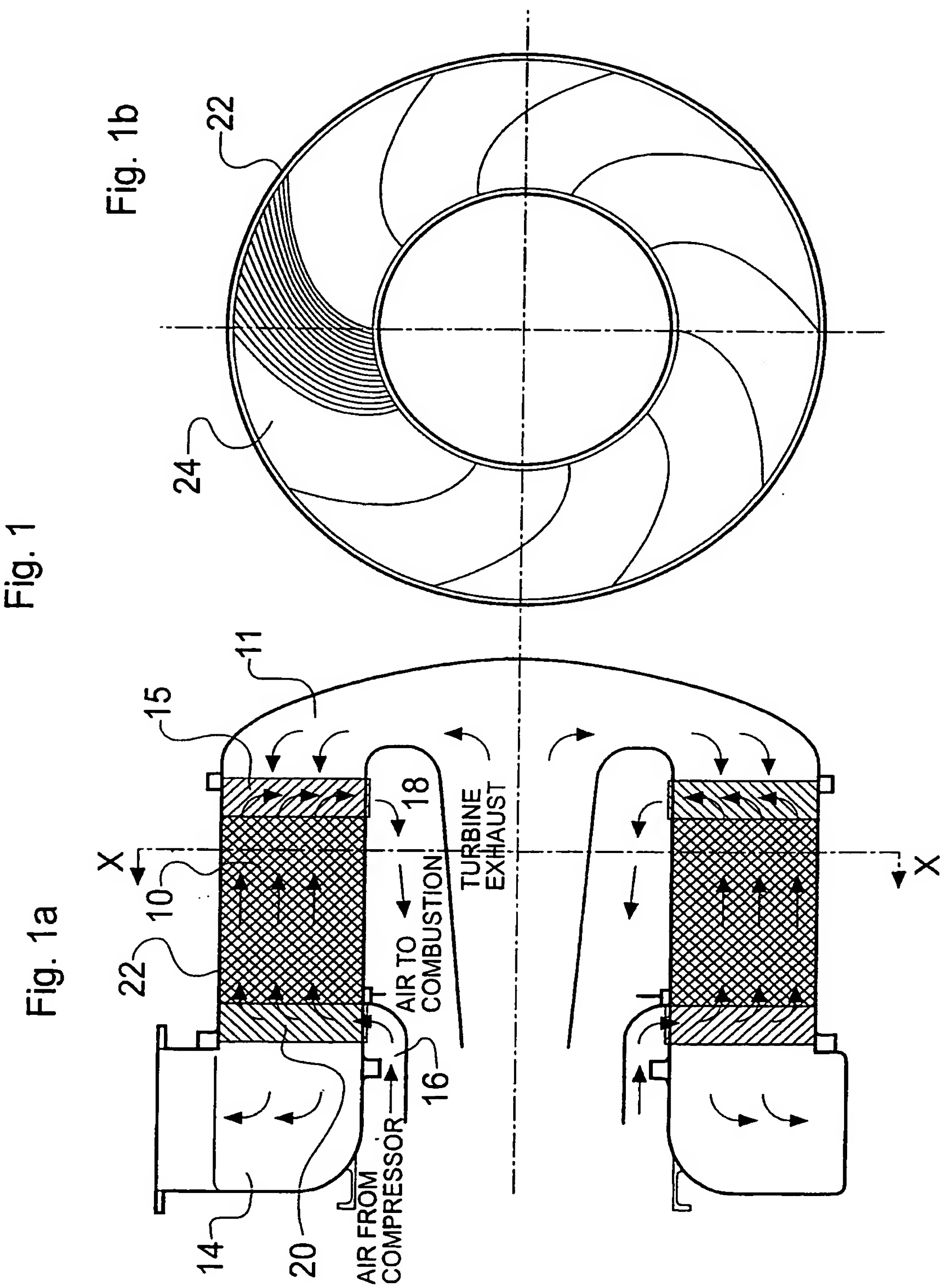


Fig. 1
Fig. 1a
Fig. 1b
22
24
11
15
18
10
X
X
22
16
14
20
AIR TO COMBUSTION
TURBINE EXHAUST
AIR FROM COMPRESSOR

Fig. 2a

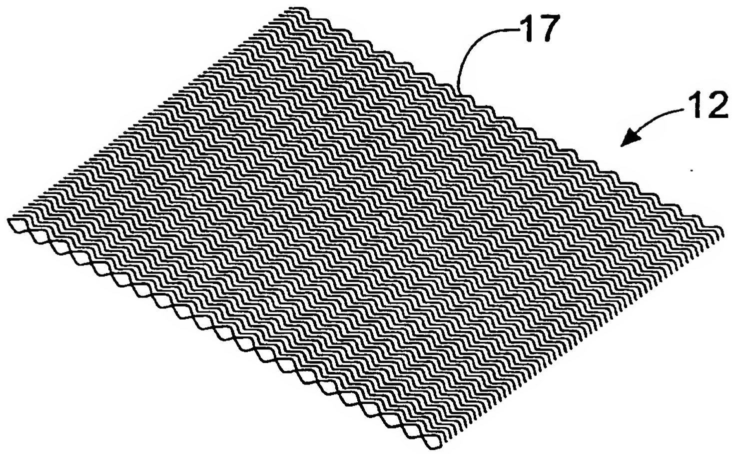


Fig. 2b

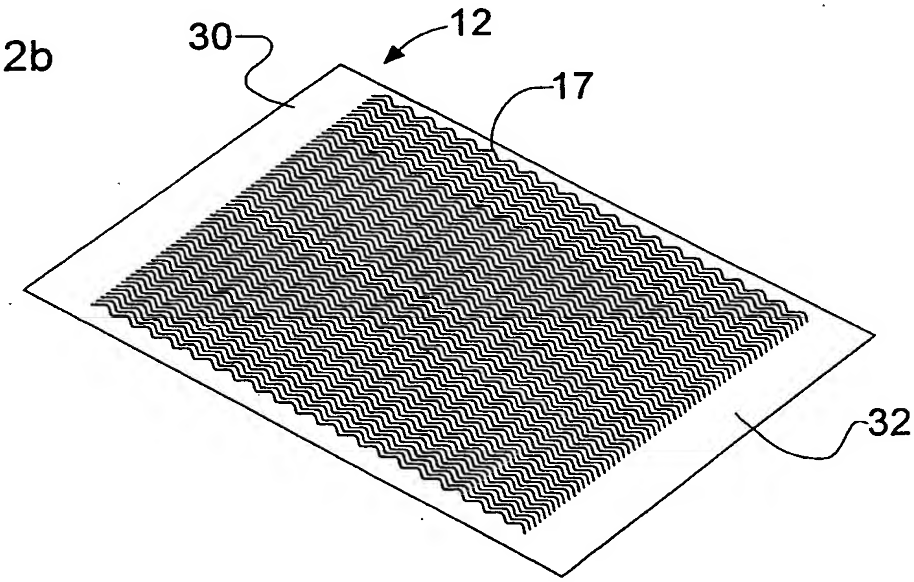


Fig. 3a

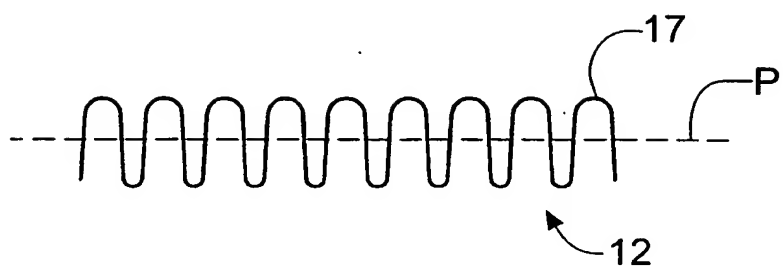


Fig. 3b

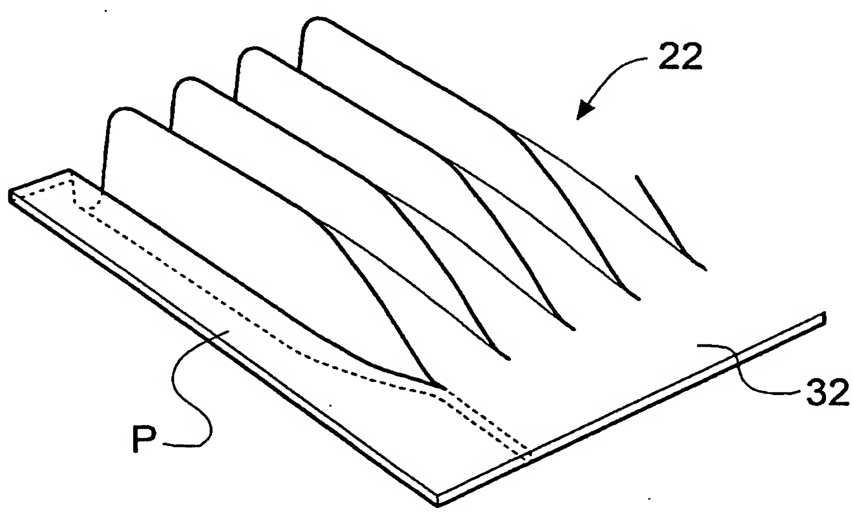


Fig. 4a

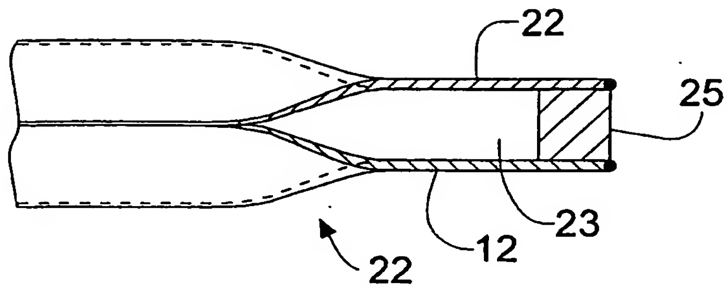


Fig. 4b

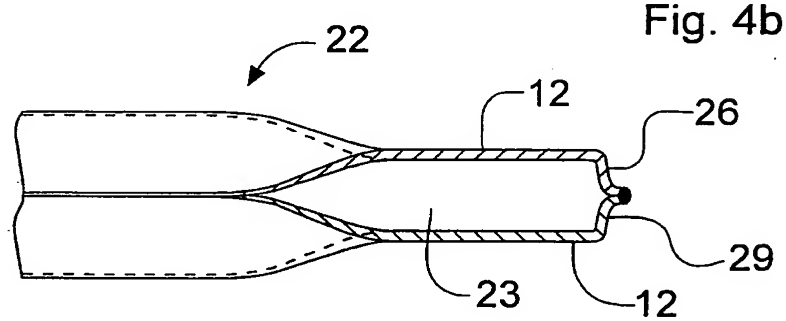
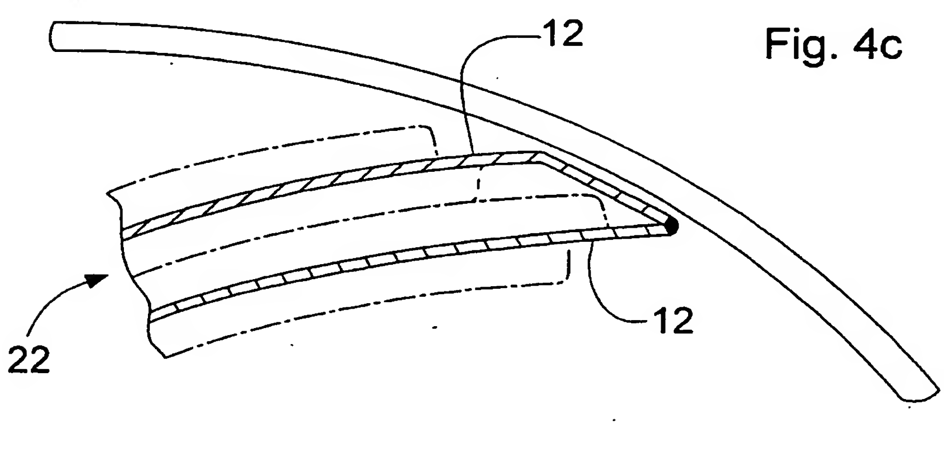


Fig. 4c



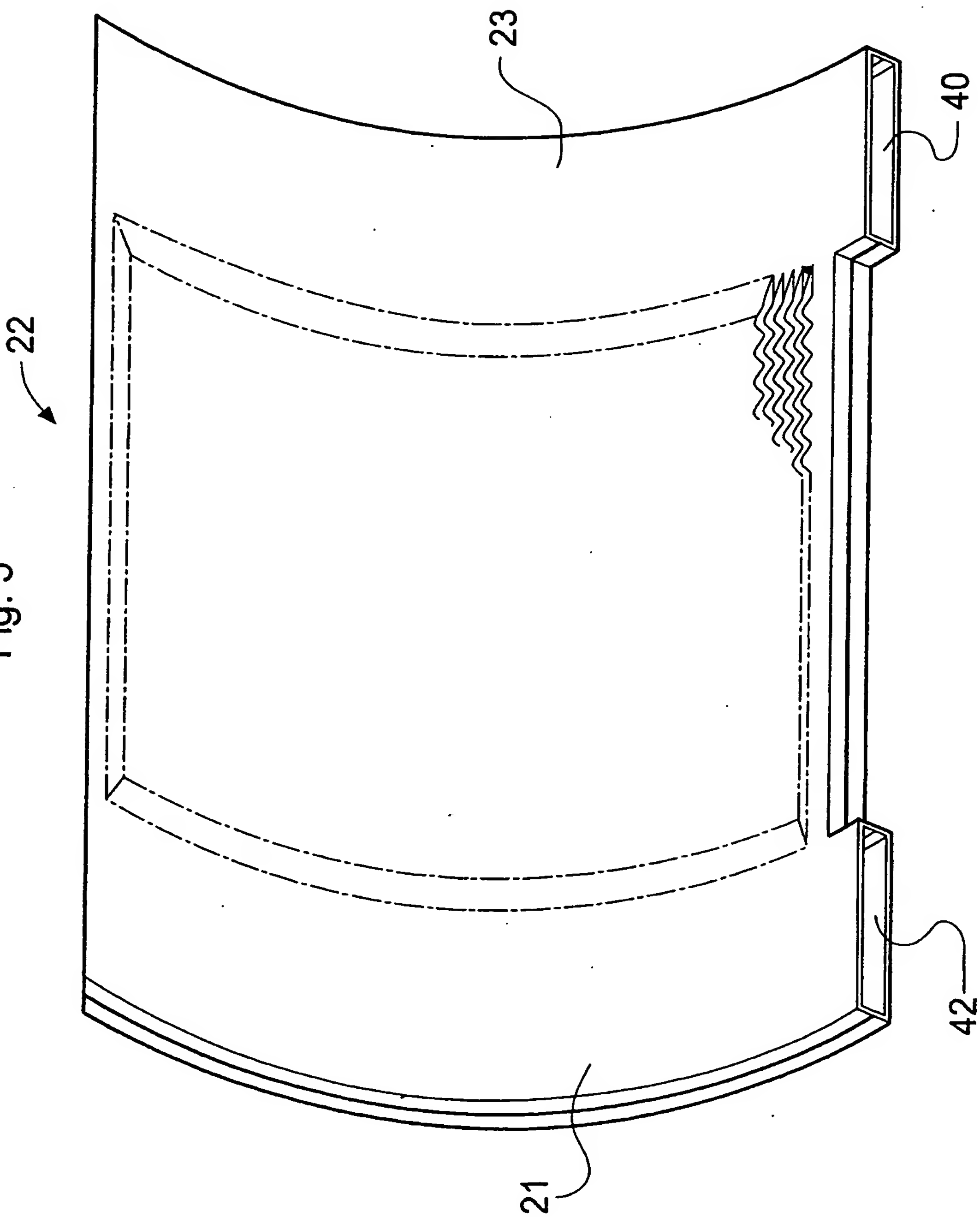


Fig. 5

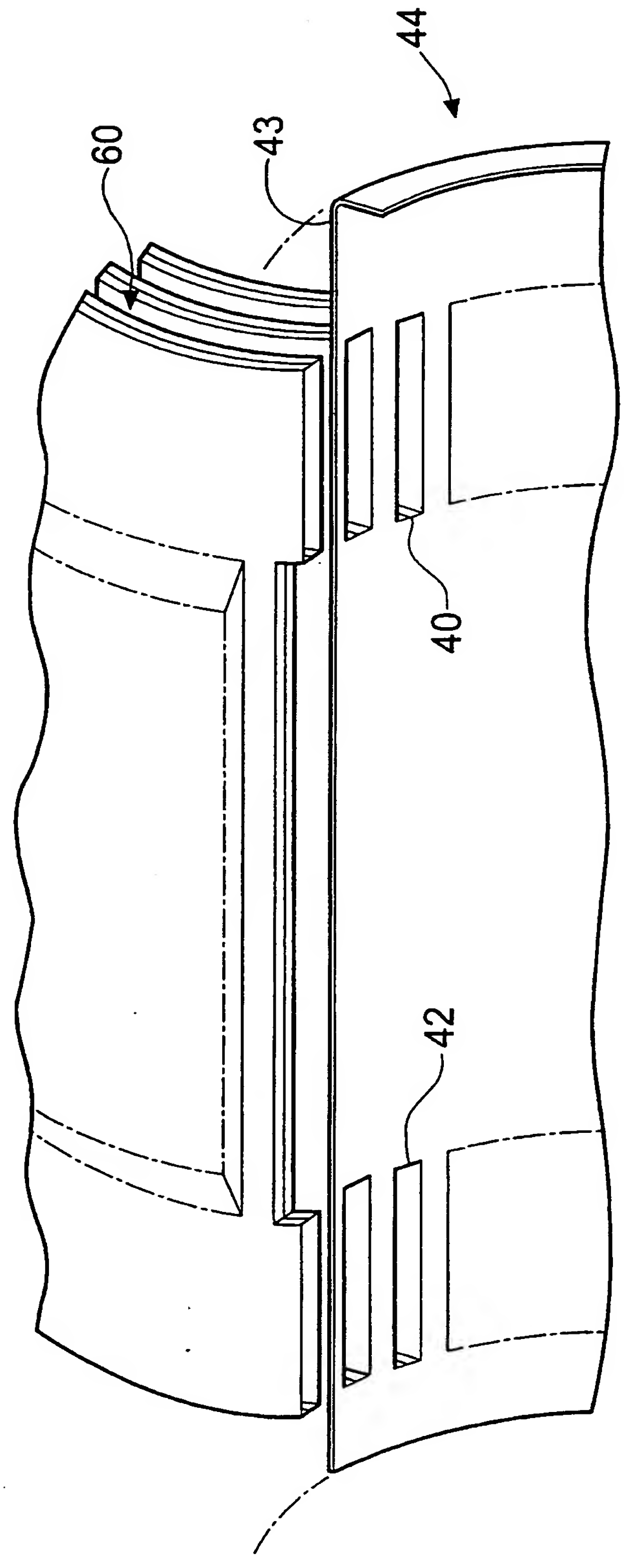


Fig. 6

Fig. 7

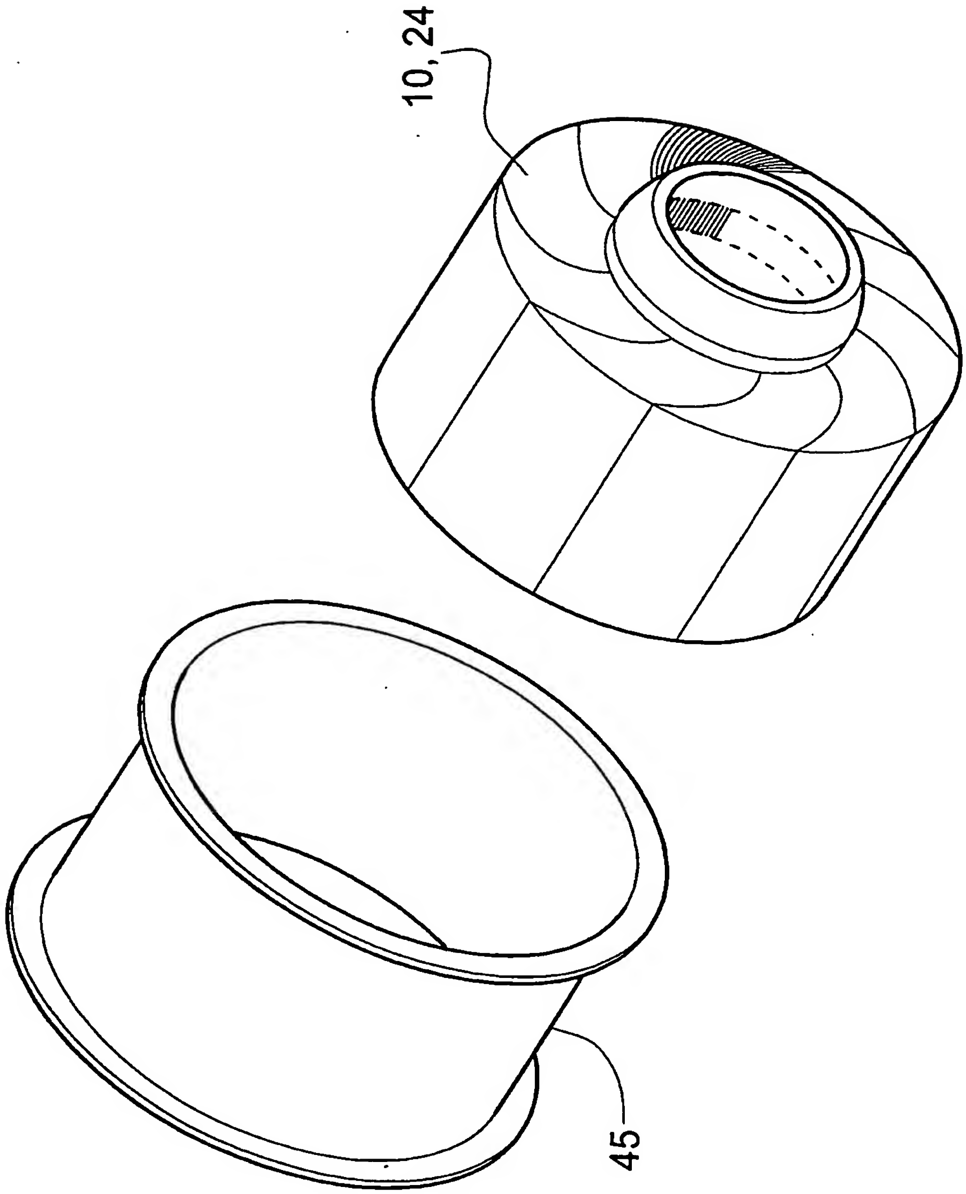


Fig. 8

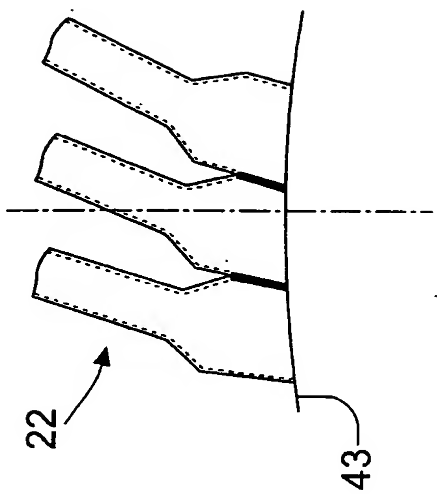


Fig. 8b

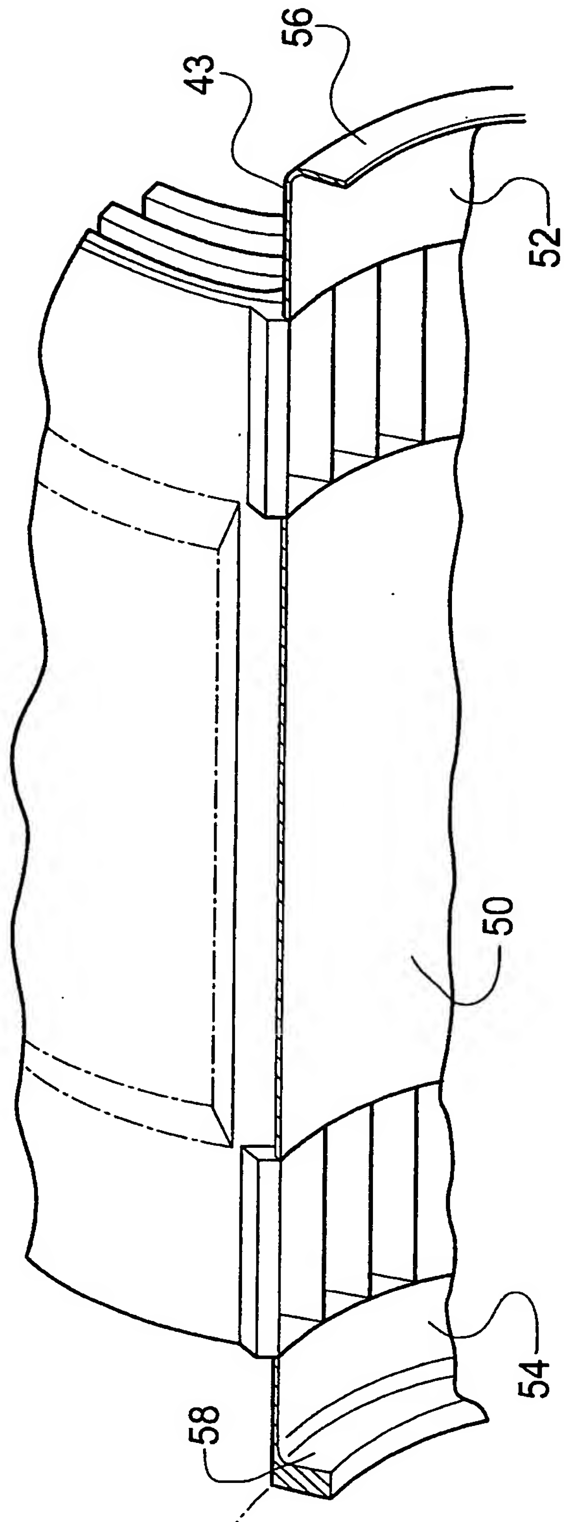


Fig. 8a

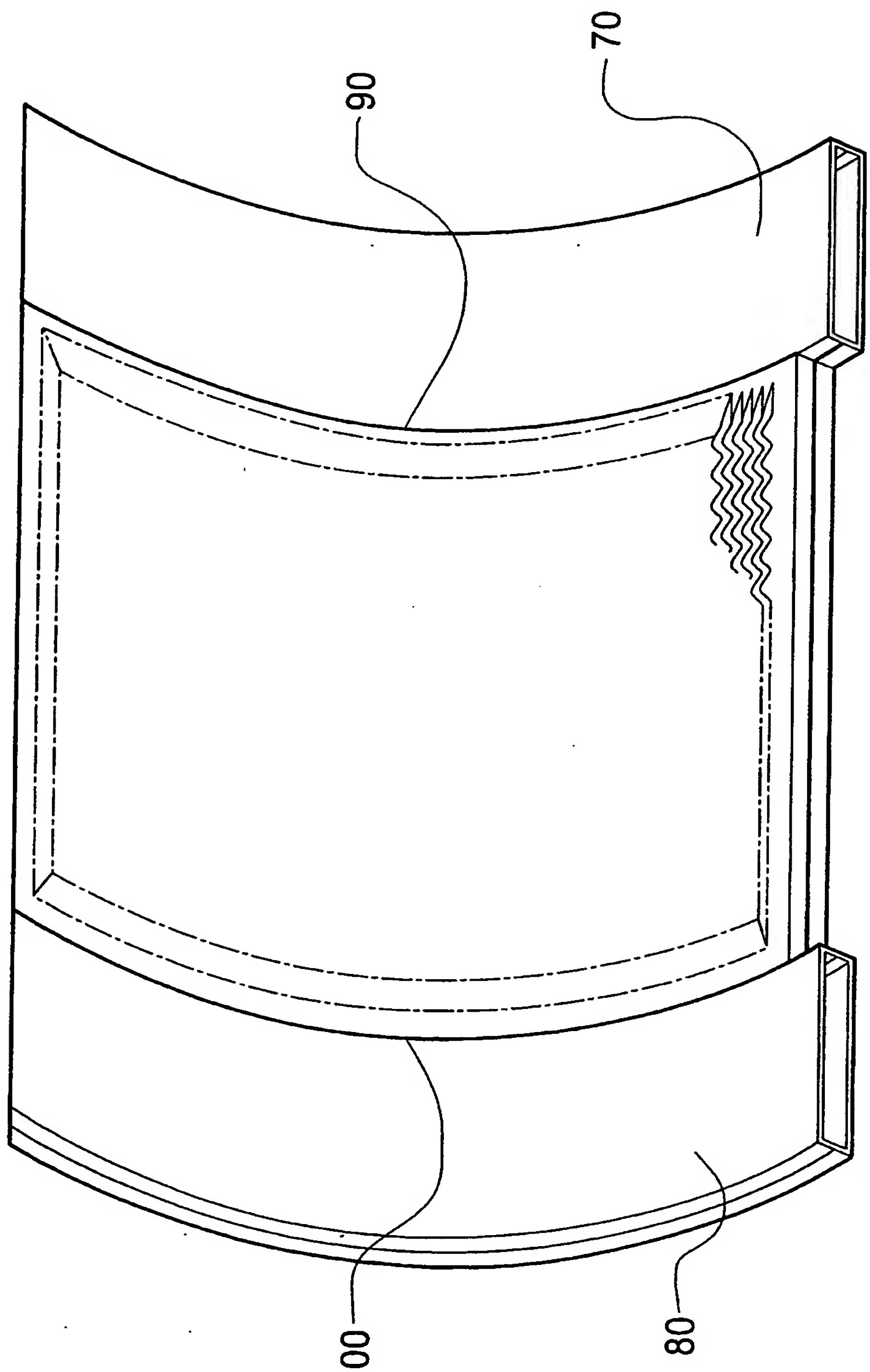


Fig. 9

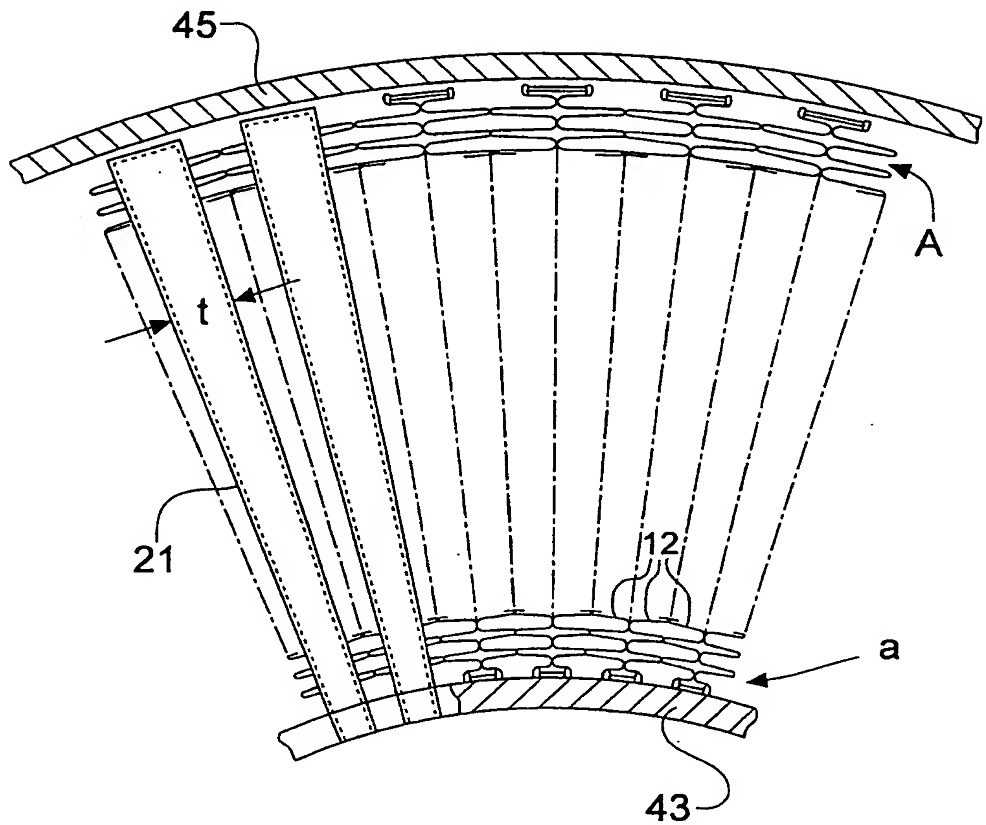


Fig. 10

INTERNATIONAL SEARCH REPORT

Intern. nal Application No
PCT/GB 99/03456

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F28D9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F28D F28F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 060 721 A (DARRAGH CHARLES T) 29 October 1991 (1991-10-29) cited in the application column 6, line 14 - line 36; figures	1-23
A	FR 2 360 058 A (SULZER AG) 24 February 1978 (1978-02-24) column 4, line 15 -column 5, line 23; figures	1-23
A	EP 0 492 799 A (ATOMIC ENERGY AUTHORITY UK) 1 July 1992 (1992-07-01) column 3, line 49 - line 53; figures	1,3
A	US 3 590 917 A (POTH LEONHARD ET AL) 6 July 1971 (1971-07-06) column 4, line 68 -column 5, line 6; figures	1,2

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[X] Further documents are listed in the continuation of box C.

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Date of the actual completion of the international search	Date of mailing of the international search report
23 February 2000	02/03/2000

Name and mailing address of the ISA	Authorized officer
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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